Global MHD Modeling of the Solar Corona and Inner Heliosphere for the Whole Heliosphere Interval

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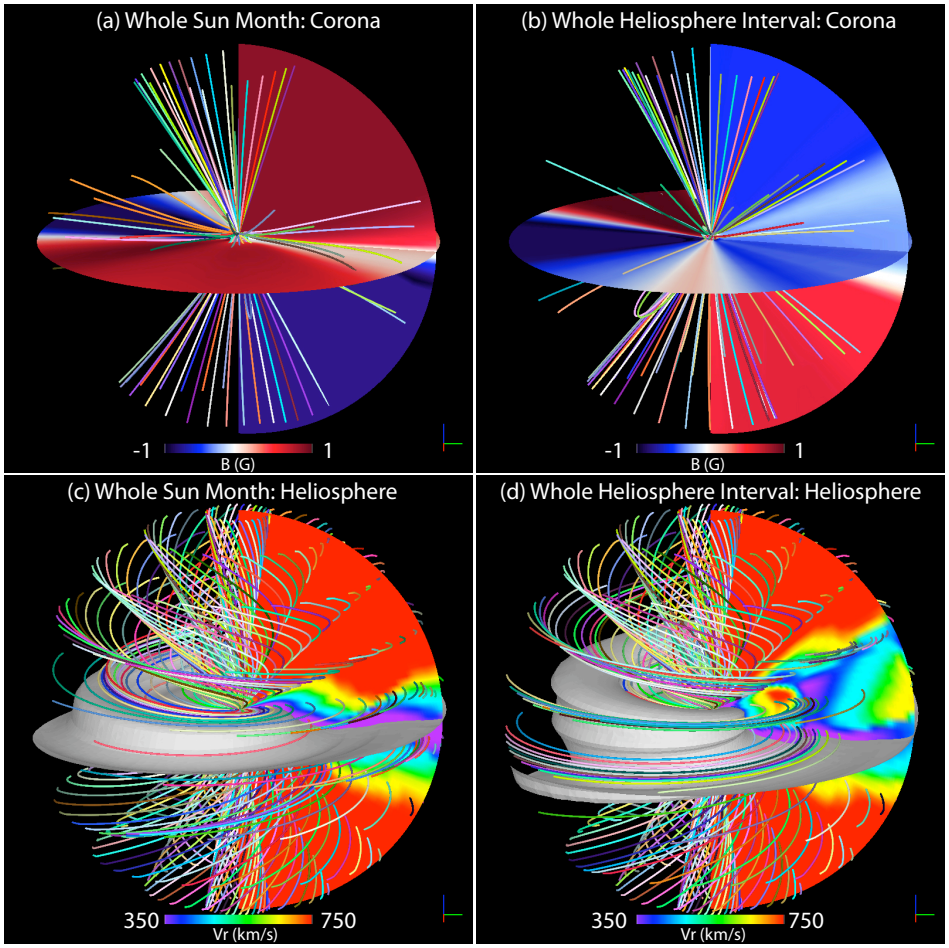
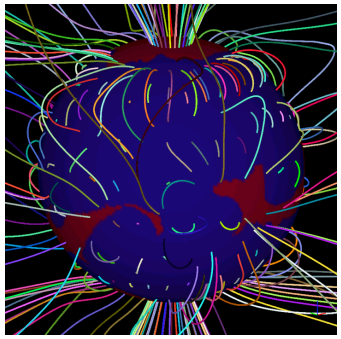
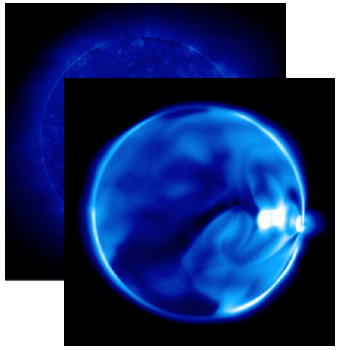


CAUTION: PRELIMINARY RESULTS

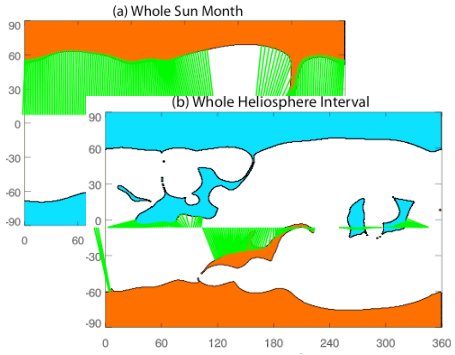
This talk explores the Whole Heliosphere Interval from the perspective of a global MHD model



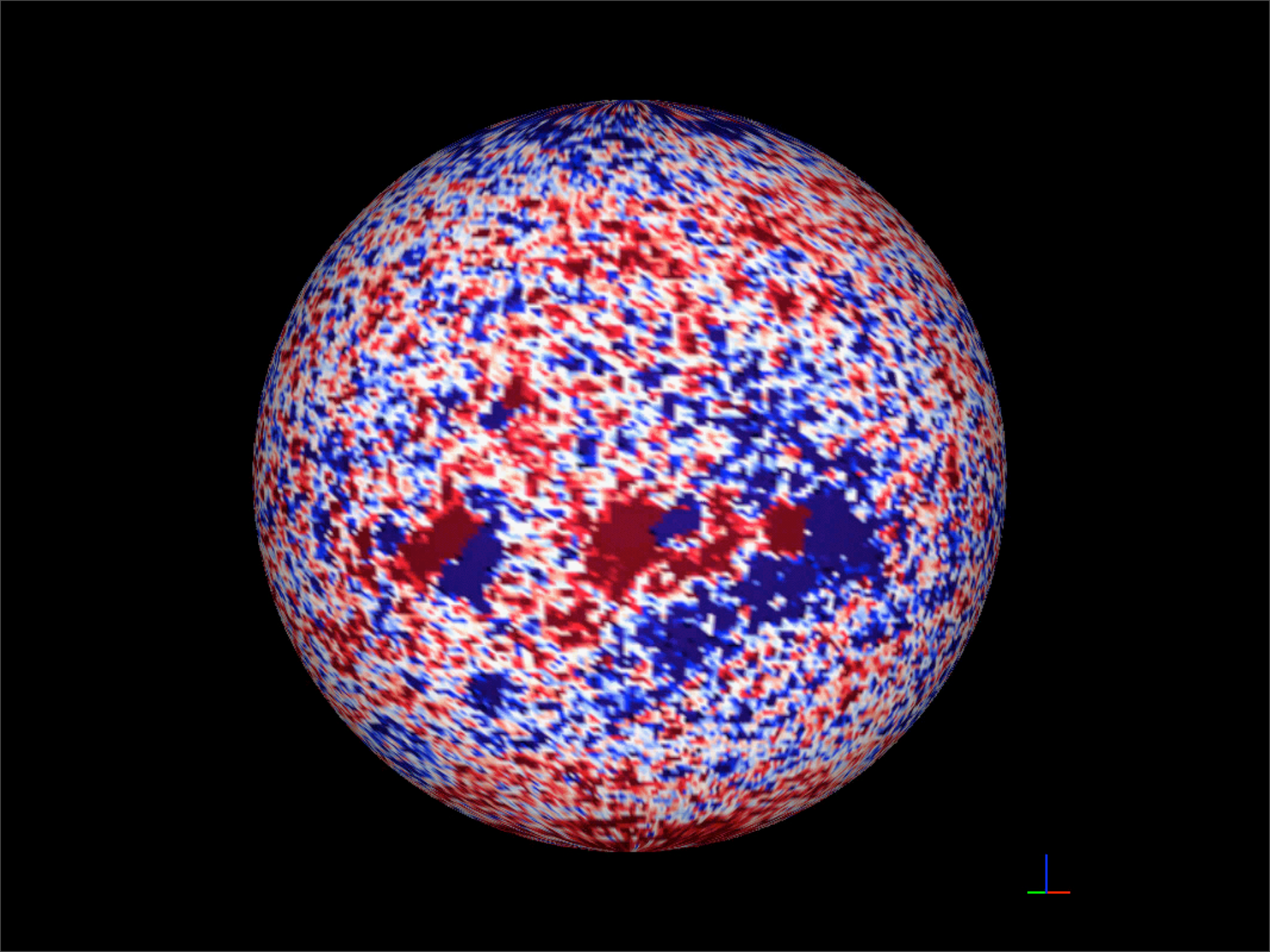
Improved MHD modeling allows us to investigate physical processes producing observed coronal and heliospheric structure.



Preliminary calculations for CR2068 show promising matches with observations, but also some disagreements.



Comparison with Whole Sun Month (WSM) shows that structure of WHI is markedly different, in spite of the 11.5 year separation



Our improved global MHD code, MAS, includes energy transport processes.

$$\nabla \times \mathbf{B} = \frac{4\pi}{c}\,\mathbf{J}$$

$$\nabla \times \mathbf{E} = -\frac{1}{c}\,\frac{\partial \mathbf{B}}{\partial t}$$

$$\mathbf{E} + \frac{1}{c}\,\mathbf{v} \times \mathbf{B} = \eta\,\mathbf{J}$$

$$\frac{\partial \rho}{\partial t} + \nabla\cdot(\rho\mathbf{v}) = 0$$

$$\rho\left(\frac{\partial \mathbf{v}}{\partial t} + \mathbf{v}\cdot\nabla\,\mathbf{v}\right) = \frac{1}{c}\,\mathbf{J}\times\mathbf{B} - \nabla p - \nabla p_w + \rho\mathbf{g} + \nabla\cdot(\nu\rho\nabla\mathbf{v})$$

$$\frac{\partial p}{\partial t} + \nabla\cdot(p\mathbf{v}) = (\gamma - 1)\left(-p\nabla\cdot\,\mathbf{v} - \nabla\cdot\,\mathbf{q} - n_e n_p Q(T) + H\right)$$

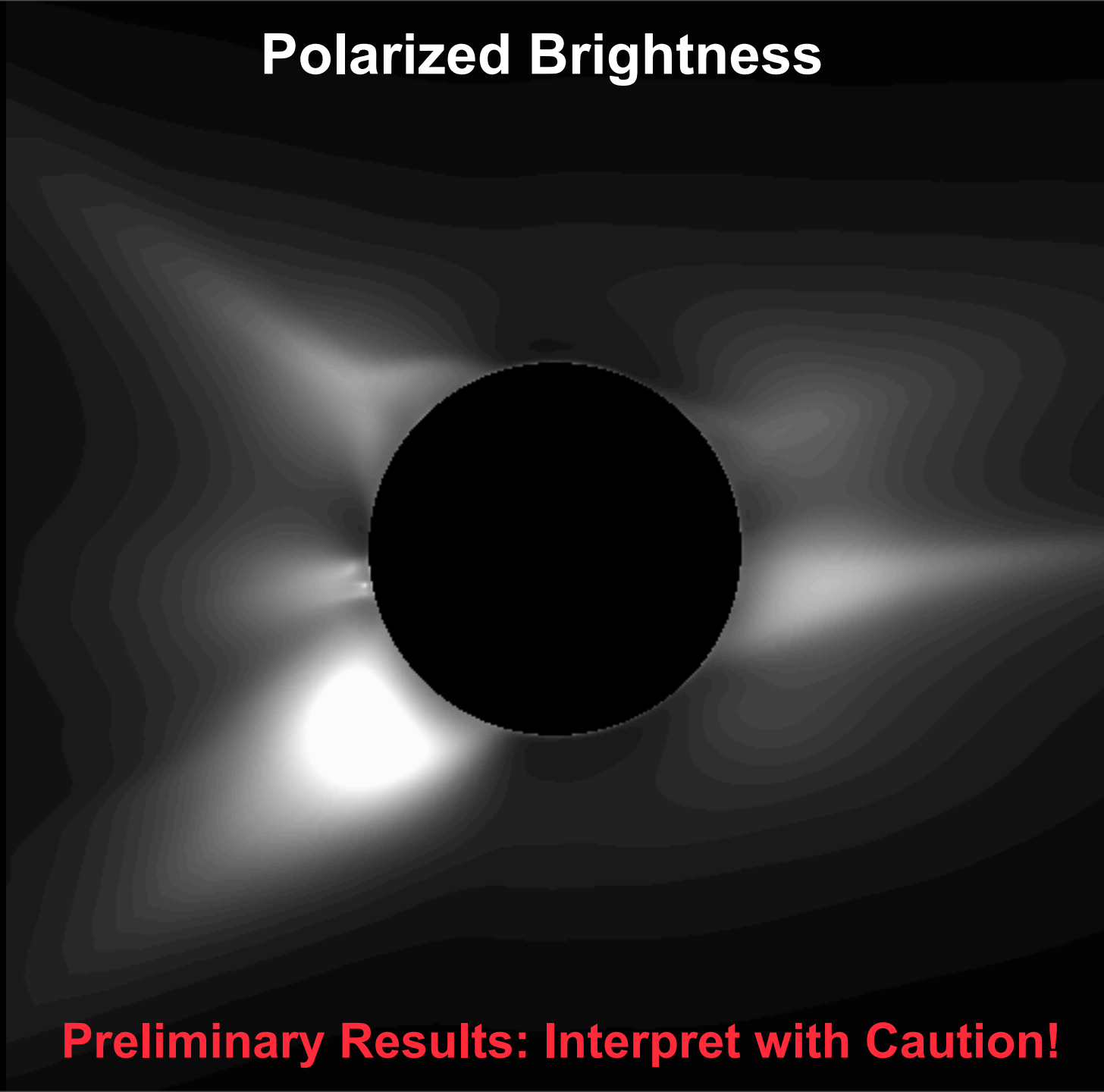
$$\gamma = 5/3$$

$$\mathbf{q} = -\kappa_{\parallel}\hat{\mathbf{b}}\hat{\mathbf{b}}\cdot\nabla T \qquad \text{(Close to the Sun, } r \lesssim 10R_S\text{)}$$

$$\mathbf{q} = 2\alpha n_e T\,\hat{\mathbf{b}}\hat{\mathbf{b}}\cdot\mathbf{v}/(\gamma - 1) \qquad \text{(Far from the Sun, } r \gtrsim 10R_S\text{)}$$

+ WKB equations for Alfvén wave pressure p_w evolution

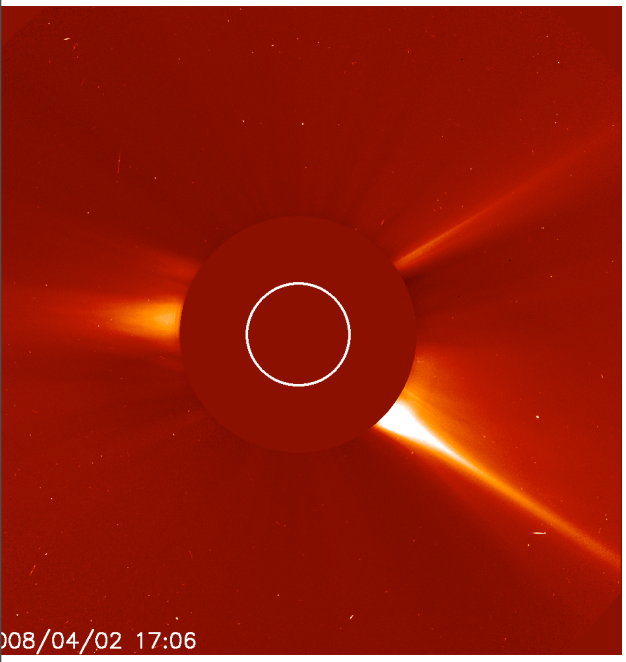
Polarized Brightness



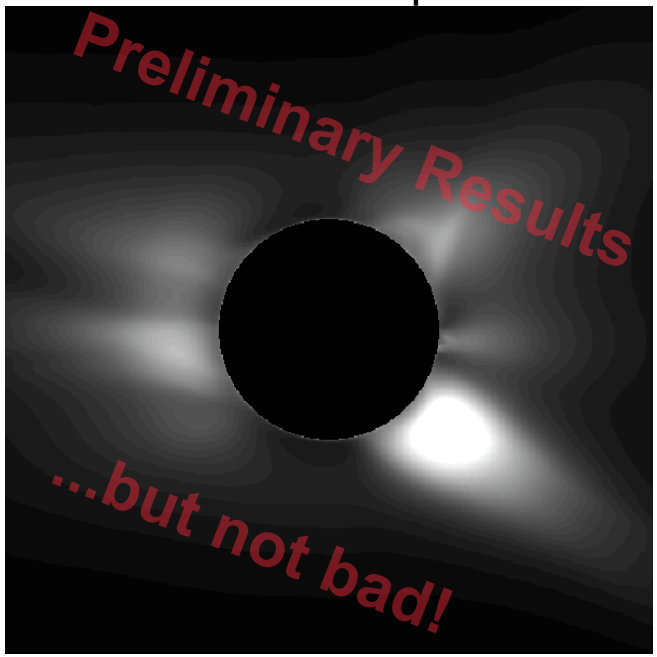
Preliminary Results: Interpret with Caution!

(Polarized) Brightness during CR 2068
April 2, 2008

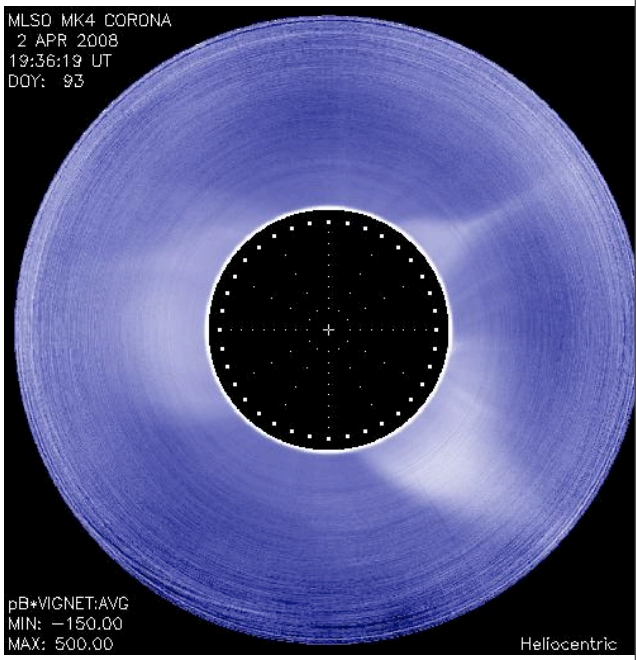
SOHO/LASCO C2



Simulated pB



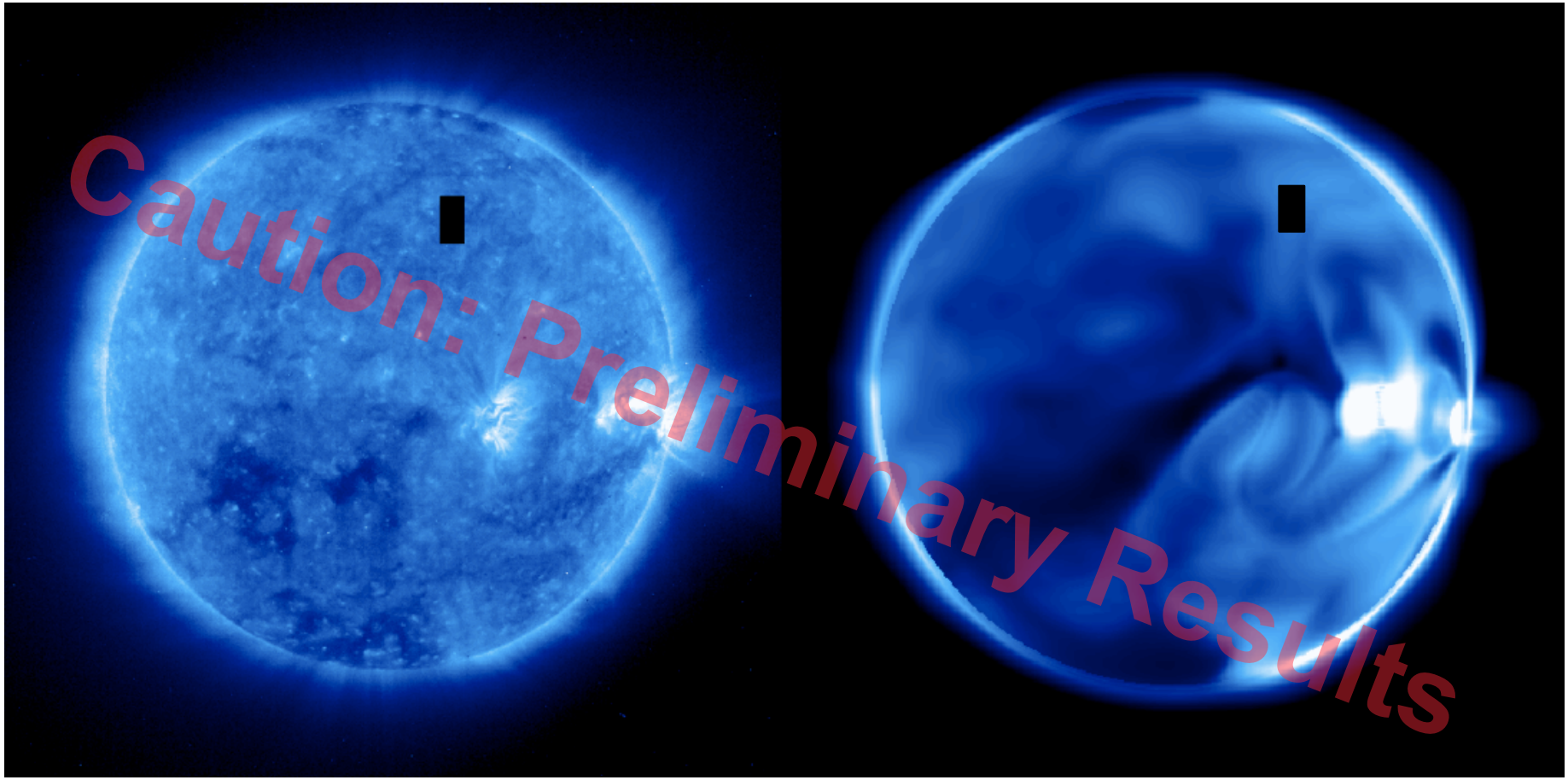
Mauna Loa



Preliminary quantitative comparisons of simulated emission with observations are promising: 171 A

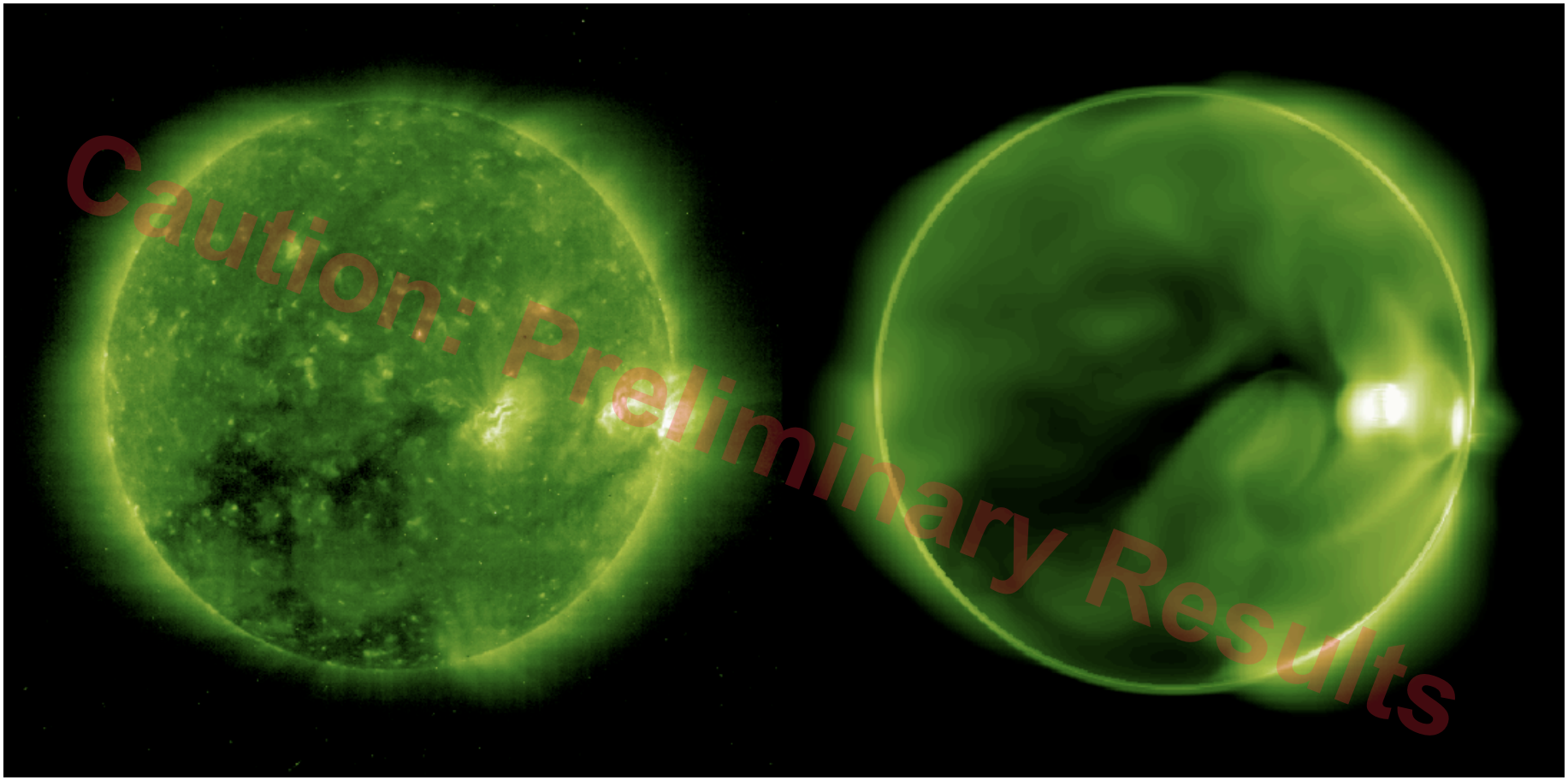
Observations

Simulations



Preliminary quantitative comparisons of simulated emission with observations are promising: 195 A

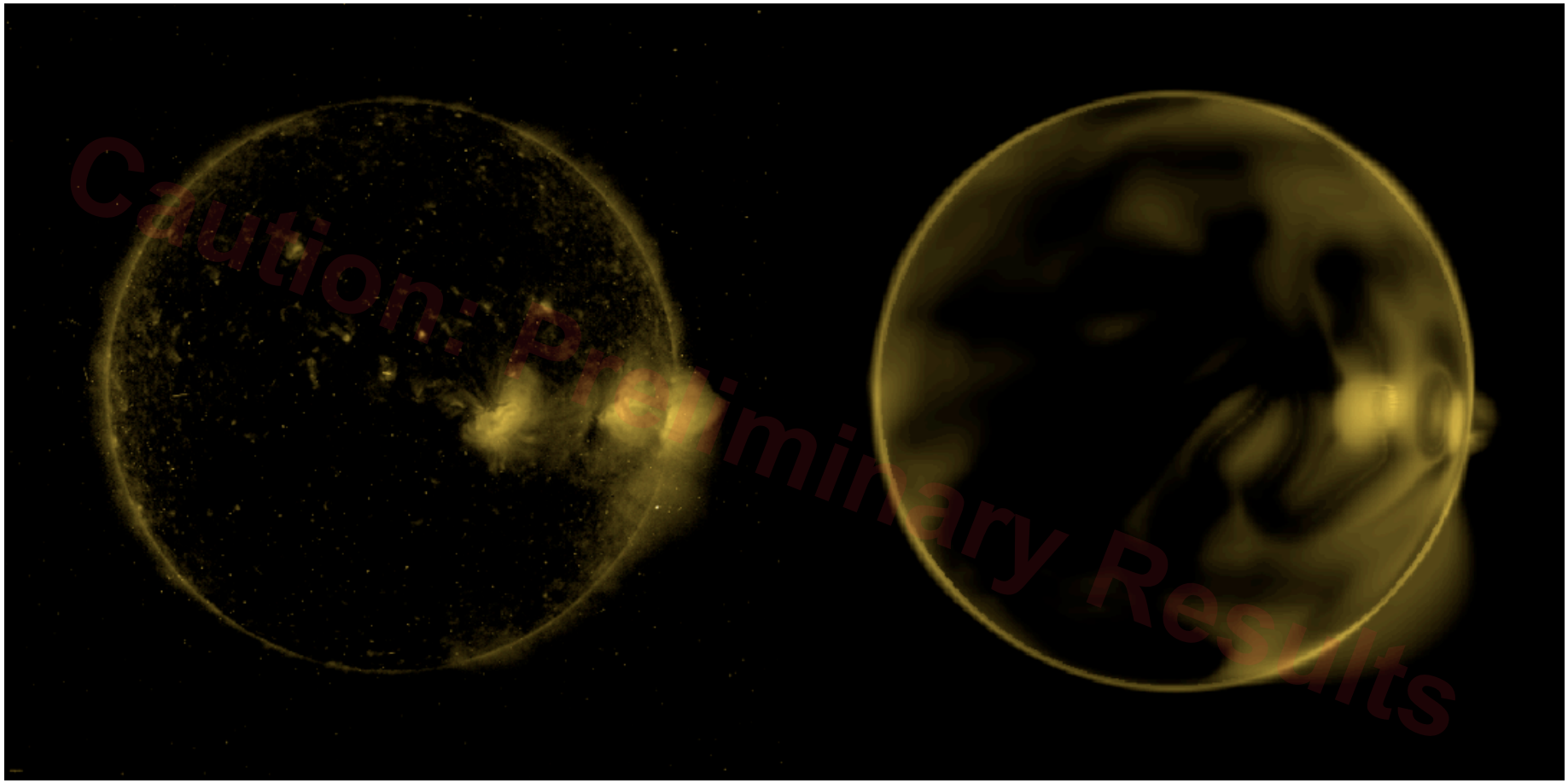
Observations Simulations



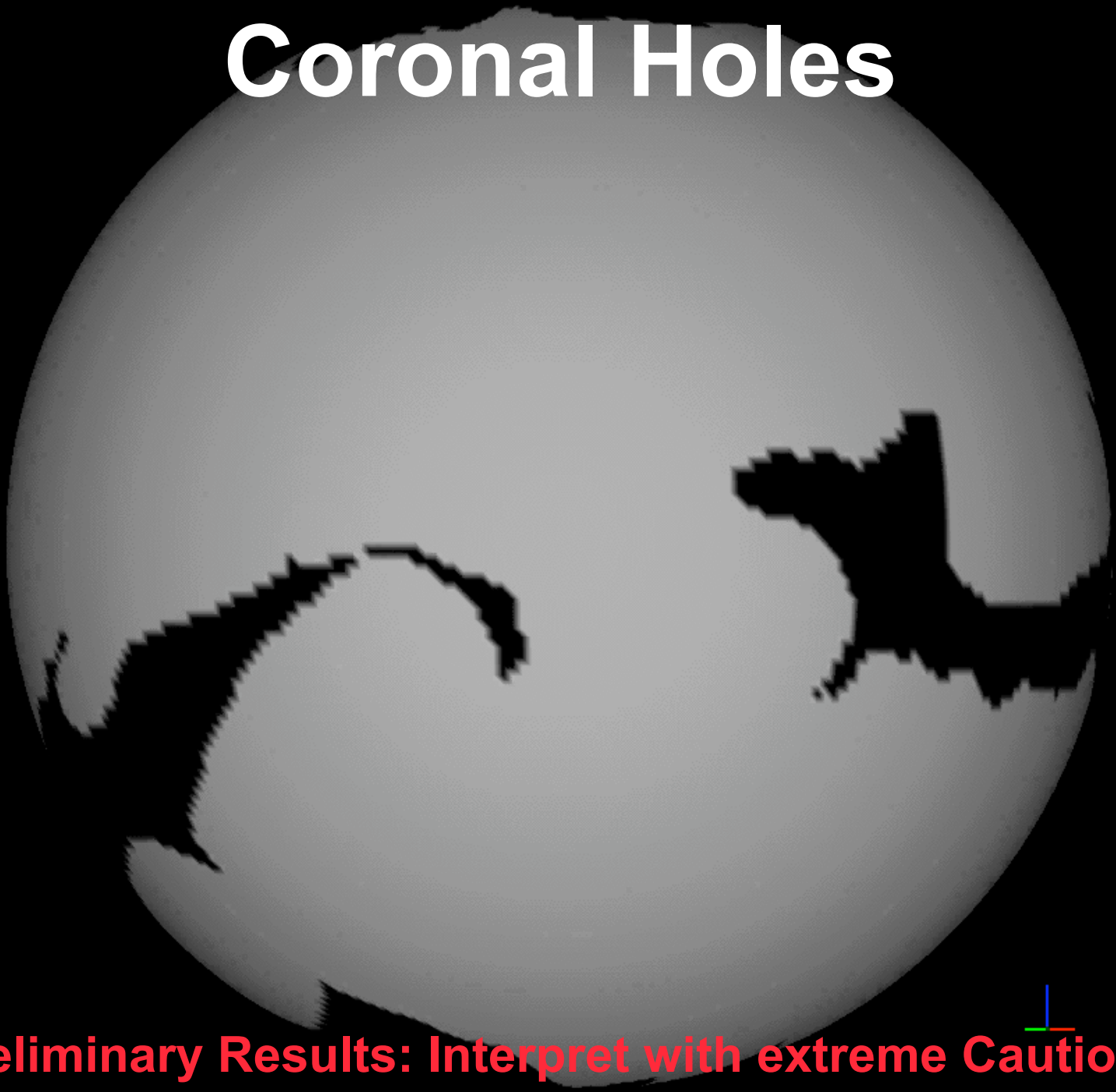
Preliminary quantitative comparisons of simulated emission with observations are promising: 284 A

Observations

Simulations



Coronal Holes

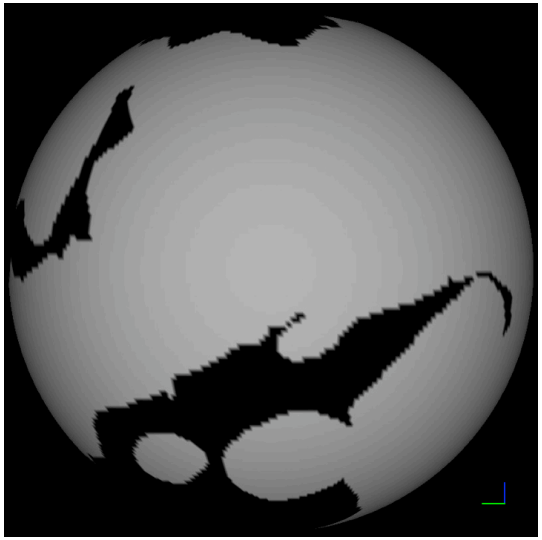


Preliminary Results: Interpret with extreme Caution!

The model predicts 3 mid-lat./eq. coronal holes

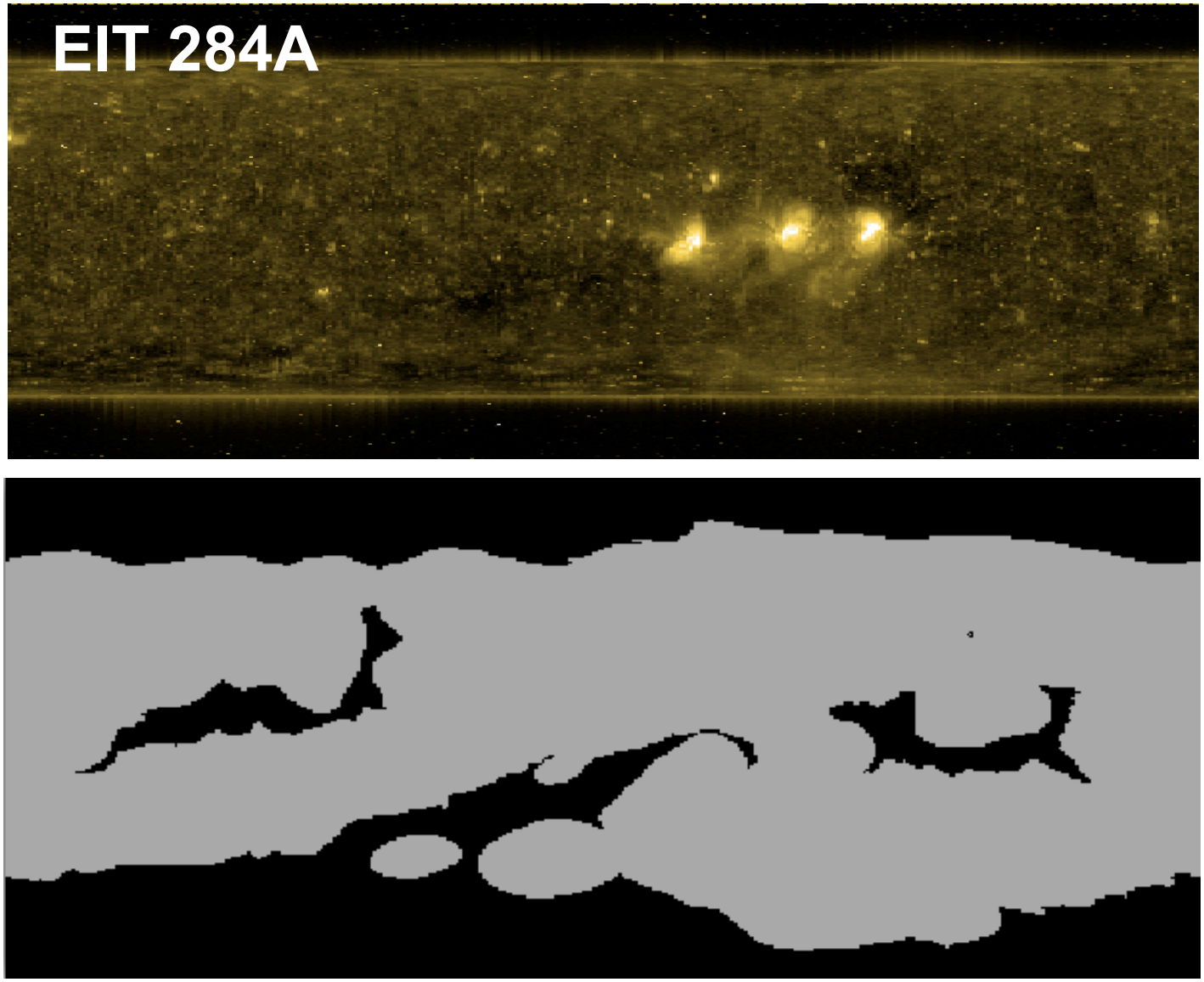
The Loch Ness Monster

The Bat

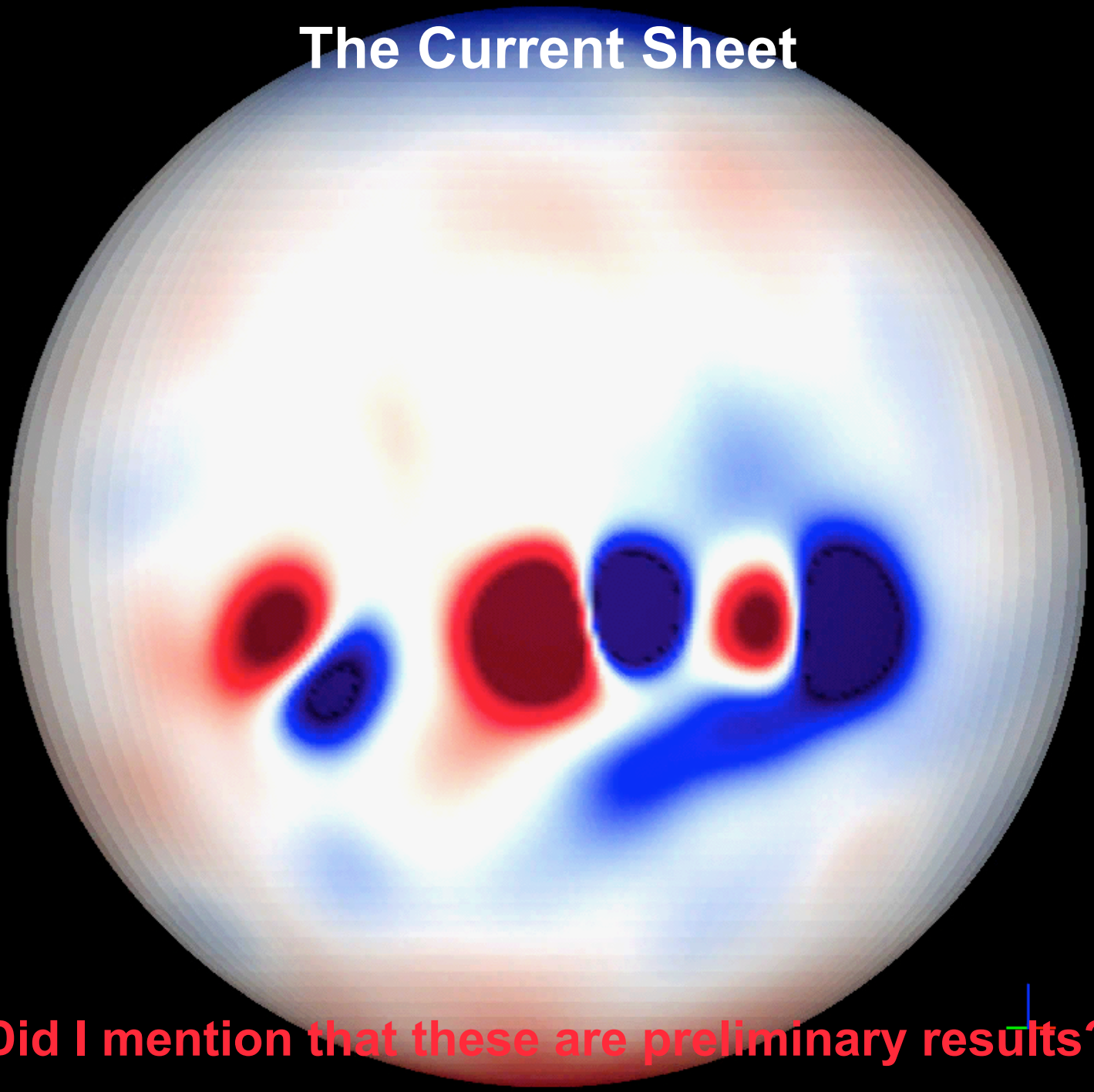


The Dog

Coronal Hole Boundaries



The Current Sheet



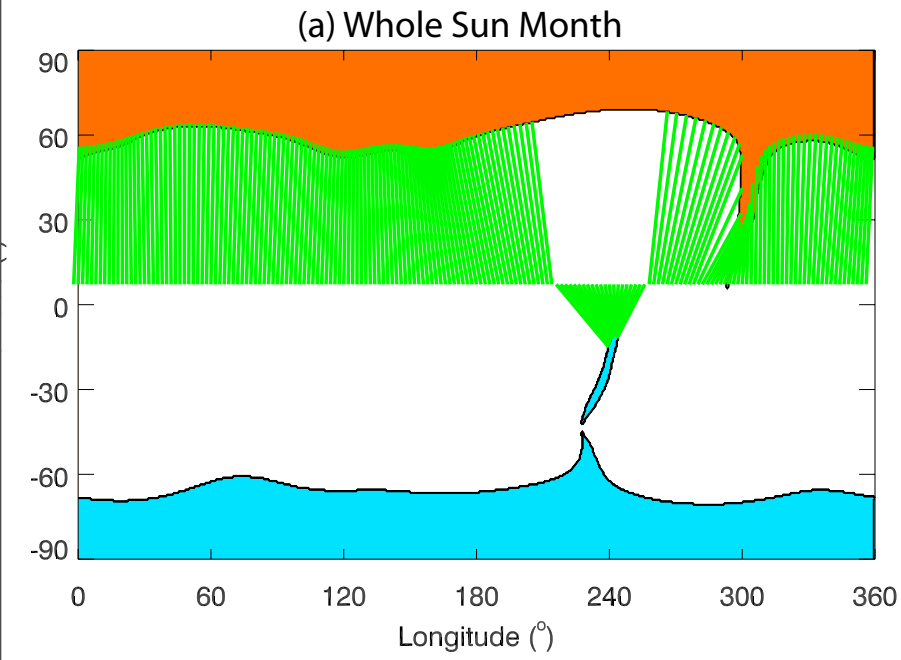
Did I mention that these are preliminary results?

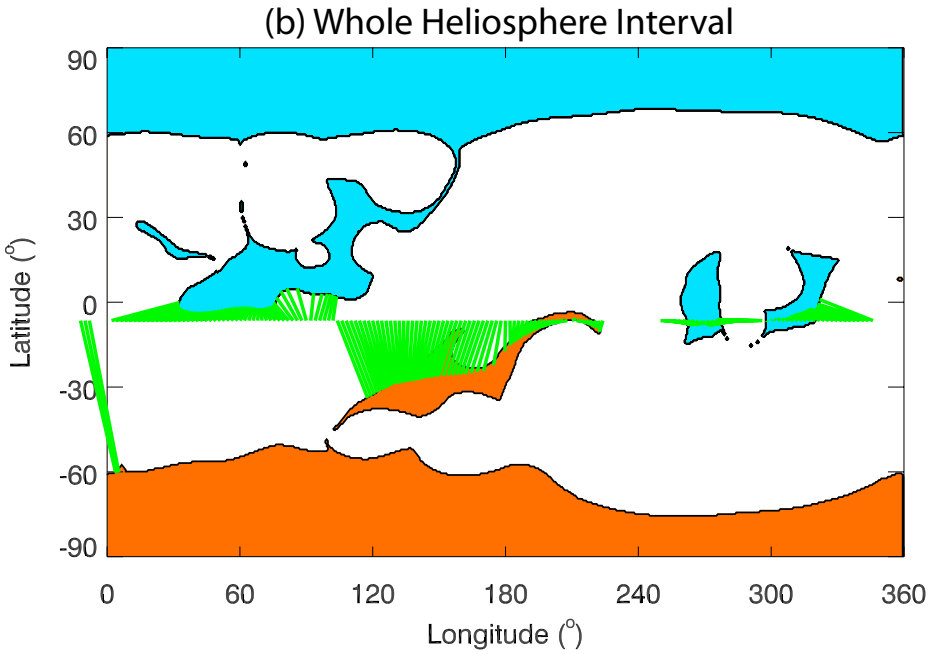
CR 1913

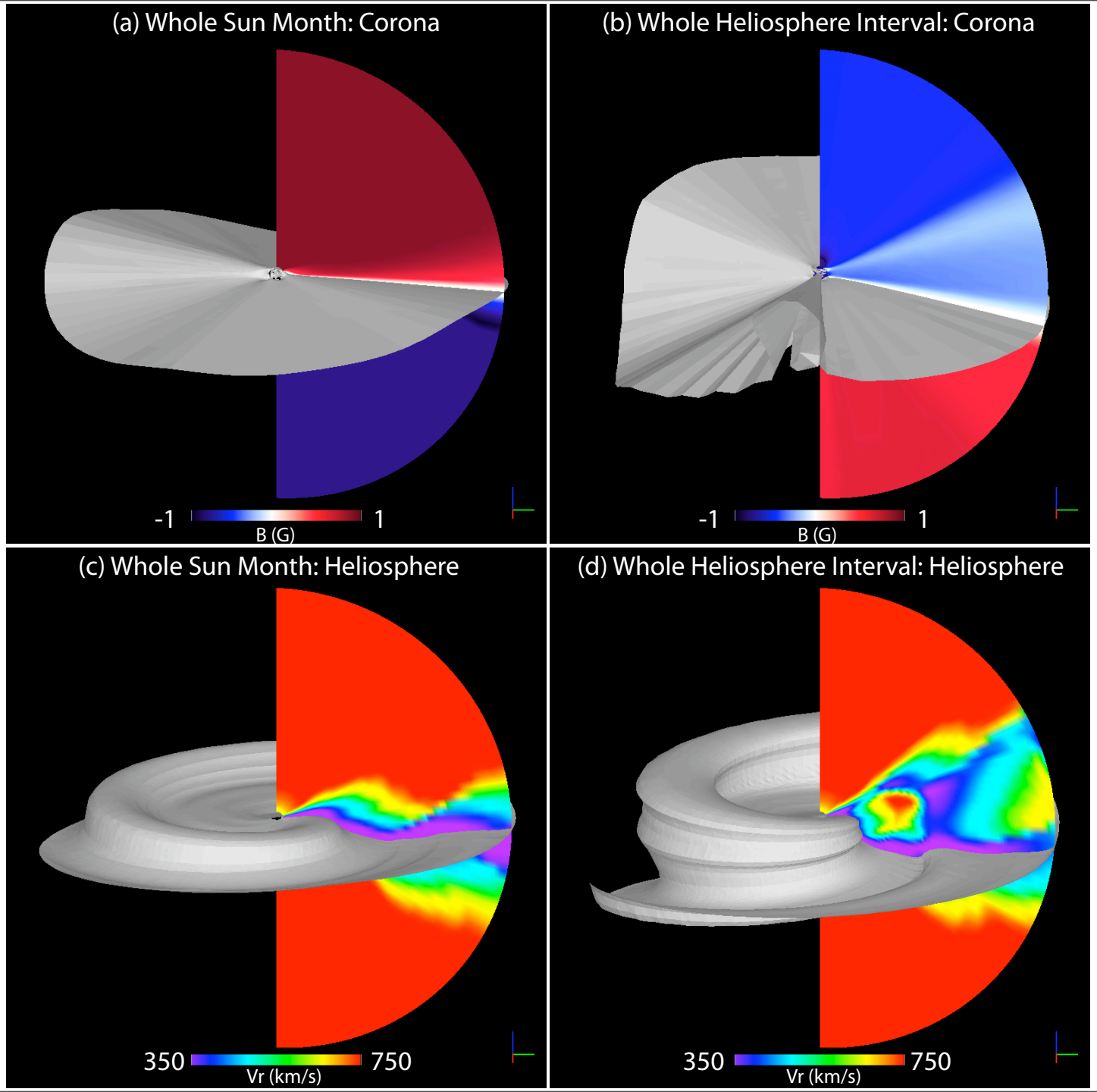
CR 2068

Are they serving beer yet?

Important differences exist between old polytropic solutions and new thermodynamic solutions.

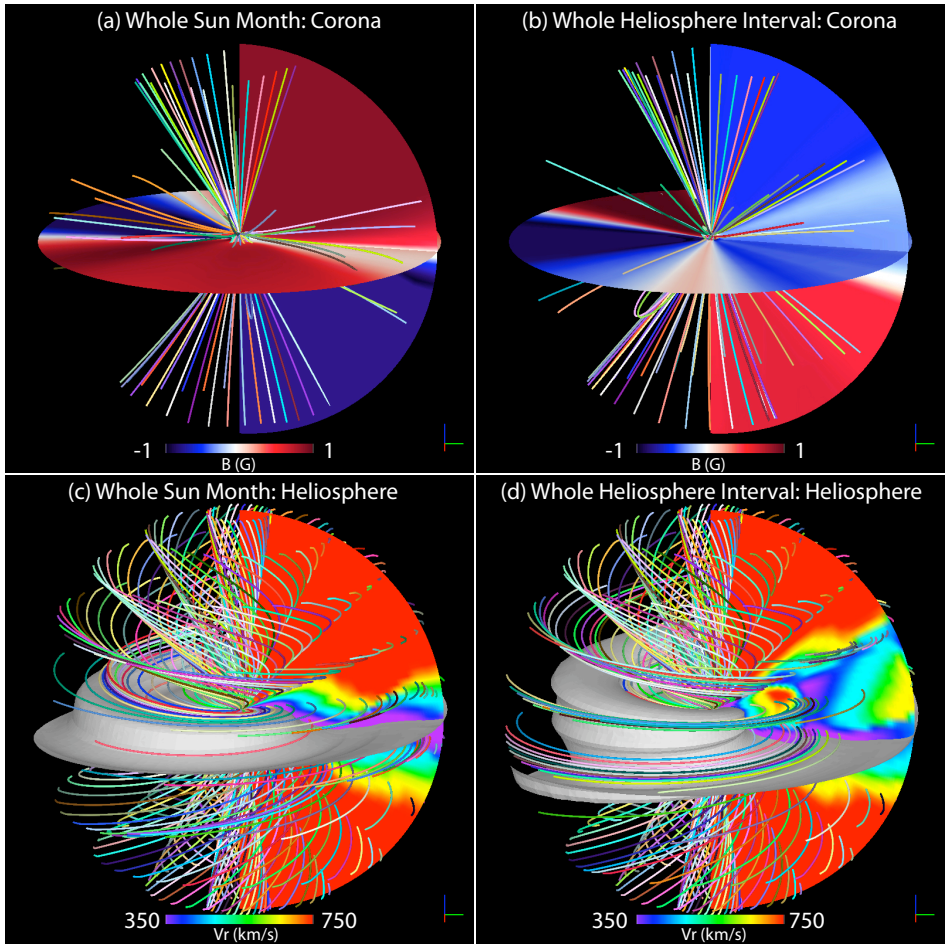





(a) Whole Sun Month: Corona
-1
1
B (G)
(b) Whole Heliosphere Interval: Corona
-1
1
B (G)
(c) Whole Sun Month: Heliosphere
350
750
Vr (km/s)
(d) Whole Heliosphere Interval: Heliosphere
350
750
Vr (km/s)

Summary

- The improved thermodynamic model will allow us to investigate coronal and heliospheric structure in more detail:
  - Quantitative emission comparisons
  - Direct comparisons with in situ measurements
  - Address topics such as the source of the solar wind
- Comparison of WHI with WSM:
  - Two intervals have markedly different structure given 11.5-year separation
  - Will allow us to explore the haracteristics of polar and equatorial sources of solar wind
- Results on the web:
  - Polytropic solutions are currently available at: http://iMHD.net/stereo
  - Thermodynamic solutions will be made available at the same location when validated



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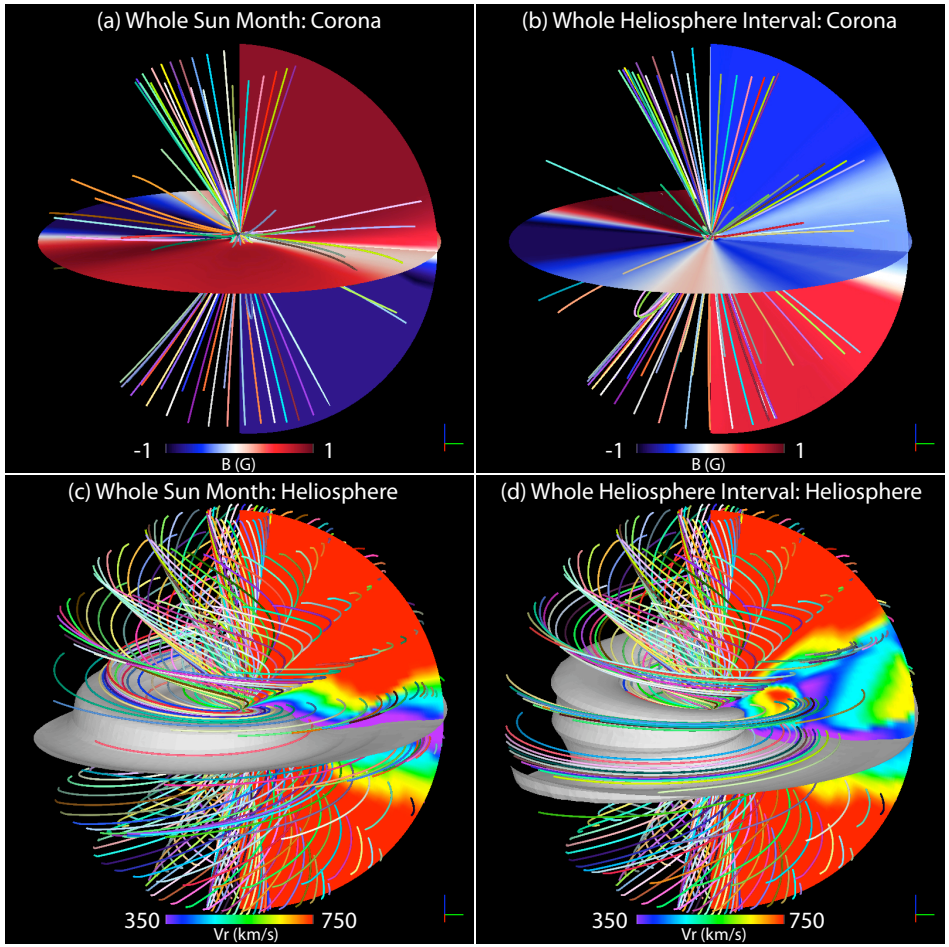

Questions?